Y/TS-51/1

403

Y-12

OAK RIDGE
Y-12
PLANT

MARTIN MARIETTA

PRELIMINARY ASSESSMENT OF EXISTING CONTAMINATION IN BEAR CREEK VALLEY WATERSHED AREA AND POTENTIAL REMEDIAL ACTIONS FOR MITIGATING ITS IMPACT ON BEAR CREEK

June 1984

Publicly Releasable

This document has received the necessary patent and technical information reviews and can be distributed without limitation.

ENVIRONMENTAL RESTORATION DIVISION
DOCUMENT MANAGEMENT CENTER
BLDG 1210 MS 7256

Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-84OR21400

ChemRisk Document No. 403

BY
ARIETTA ENERGY SYSTEMS, INC.
NITED STATES
NT OF ENERGY

COPY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

June 15, 1984 Y/TS-51/1

PRELIMINARY ASSESSMENT OF EXISTING CONTAMINATION IN BEAR CREEK VALLEY WATERSHED AREA AND POTENTIAL REMEDIAL ACTIONS FOR MITIGATING ITS IMPACT ON BEAR CREEK

Health, Safety, Environment, and Accountability Division

Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-84OR21400

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES*

*See document Y/TS-51/2, "Appendices: Preliminary Assessment of Existing Contamination in Bear Creek Valley Watershed Area and Potential Remedial Actions for Mitigating Its Impact on Bear Creek"

1.0 EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) is presently conducting a series of investigations at its Y-12 Plant in Oak Ridge, Tennessee, concerning contamination at several waste disposal areas in Bear Creek Valley. The investigations were initiated in 1983 when the Tennessee Department of Health and Environment (TDHE) expressed concern over the presence of contaminants in Bear Creek and requested DOE to evaluate whether those contaminants could be adversely affecting fish, other aquatic organisms, and the water quality of the stream. The principal finding of the investigation thus far is that there is no imminent hazard or risk to public health, but that the contamination will require remedial actions to minimize potential adverse impacts.

The evidence in-hand shows concentrations of volatile organic compounds in Bear Creek and some of its tributaries, and also indicates that these same compounds, together with above-background concentrations of metals and other waste constituents, are present in the shallow ground-water system immediately adjacent to the waste disposal facilities. The contaminated ground water is moving very slowly, and has not been detected at distances greater than about 1,000 feet from any waste source. No wells are used for drinking water purposes in Bear Creek Valley nor is water taken directly from Bear Creek for this purpose.

DOE presently plans to complete a second phase of investigations by mid-CY-1985 at which time a plan for remedying the situation will be submitted to the TDHE and the Environmental Protection Agency (EPA). That plan will define the steps to be taken to reduce seepage of contaminants from the wastes and to control the movement of contaminated water toward and into the surface and ground waters. The remedial work may involve installation of water treatment facilities, recovery wells, drains, and subsurface cutoff walls. This report assesses the extent of the contamination determined to date, the methods available for its control, a review of the additional investigations to be undertaken, and a schedule for completing the proposed investigations and remedial action options studies.

2.0 INTRODUCTION

2.1 BACKGROUND

A Memorandum of Understanding (MOU) was signed on May 26, 1983, by representatives of the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Tennessee Department of Health and Environment (TDHE) relative to environmental pollution control measures at the Y-12 Plant of DOE in Anderson County, Tennessee. In the MOU, the parties agreed on the objectives of a compliance program to address reported serious environmental problems associated with waste disposal practices at the Y-12 Plant. In December 1983, James E. Word, Commissioner of the TDHE, issued Complaint and Order No. 83-228 on Bear Creek Valley. Relief Condition 6 states the following:

> "That DOE shall submit to TDHE a written proposal with supporting data and rationale, and schedule for remedial action for the Bear Creek Watershed Area including, but not limited to, the Oil Farm Area, Isolation Area, Burial Ground Disposal Pits, and Stand Pipe Area by July 1, 1984. Said remedial action may include the elimination of the source of PCB and other contaminants from the area."

This report was prepared to satisfy Relief Condition 6 in the Complaint and Order and the contents of Commissioner J. E. Word's May 10, 1984, letter to Mr. Joe LaGrone, Manager, Oak Ridge Operations, U.S. Department of Energy.

The Y-12 Plant was built by the U.S. Army Corps of Engineers in 1943 as part of the Manhattan Project. Its original mission was to separate the fissile isotope of uranium from natural uranium by the electromagnetic process, but after World War II, that process was discontinued in favor of the gaseous diffusion process. Since then, the plant has developed into a highly sophisticated manufacturing, development, and engineering organization. Presently, the plant (1) produces nuclear weapons components in support of DOE's weapons design laboratories, (2) processes special materials, (3) supports other Oak Ridge and Paducah installations, and (4) supports other governmental agencies. Figure 2-1 shows the general location of the Y-12 Plant and two of its waste disposal facilities.

The Y-12 Plant is located at the eastern end of Bear Creek Valley in the valley-and-ridge section of east Tennessee. Since 1951, it has used land-disposal facilities located approximately one mile west of the Y-12 Plant and within the Bear Creek Watershed. There are three principal unclosed waste disposal areas; the S-3 ponds (started in 1951), the oil landfarm started in 1973), and the burial grounds (started in 1955). Figure 2-2 shows the locations of these disposal sites within the valley.

2.2 SITE DESCRIPTION

Bear Creek Valley, which extends in a northeast-southwest direction, is bordered to the north by Pine Ridge and to the south by Chestnut Ridge. The crests of the ridges are generally several hundred feet higher than the floor of the valley, which is a few thousand feet wide in most places. Bear Creek originates near the S-3 ponds and follows a general southwesterly course past the oil landfarm and burial ground sites until it discharges into the East

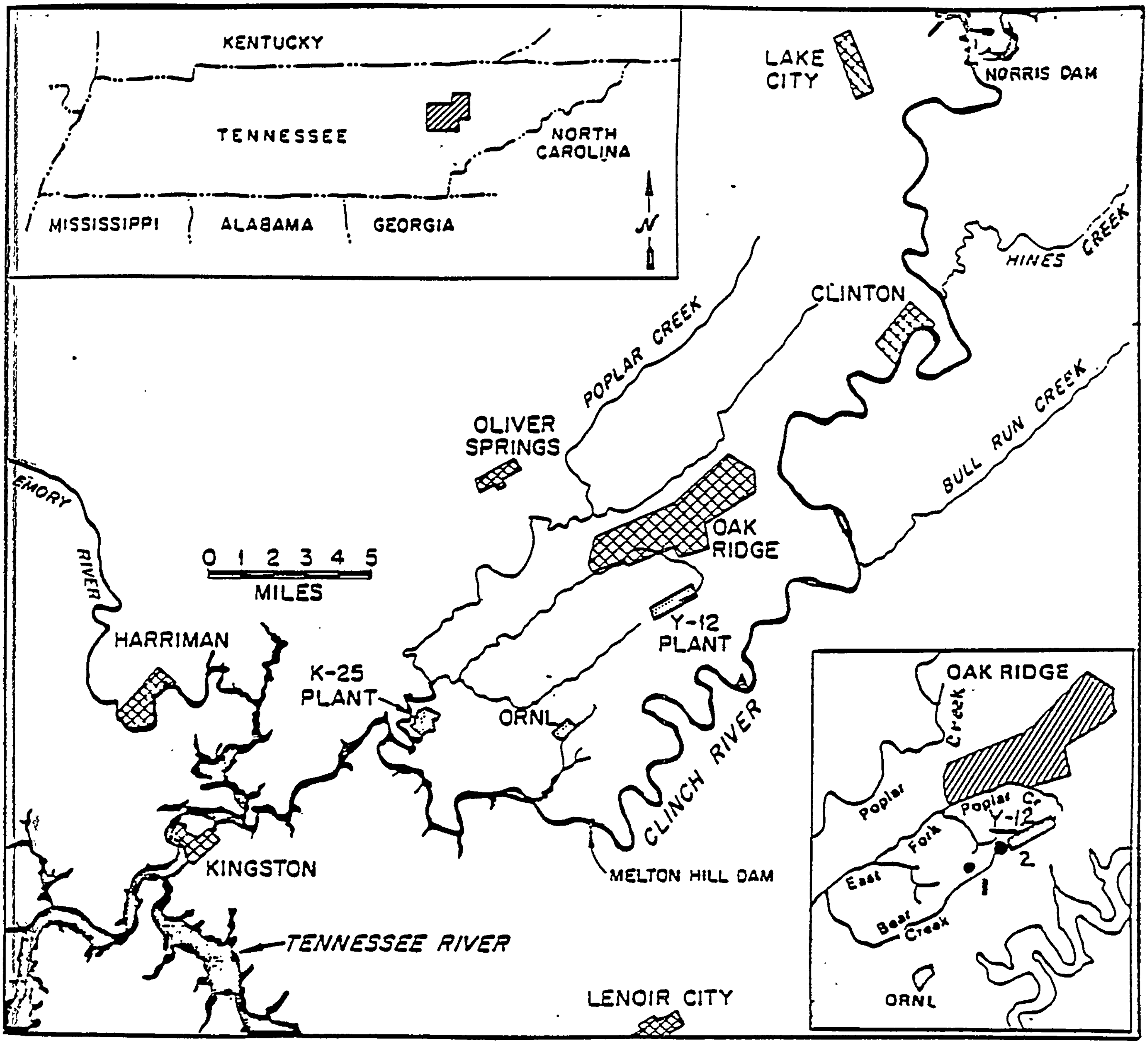


Figure 2-1. Location of the Y-12 Plant
Legend: 1. Bear Creek Valley Waste Disposal Area;
2. S-3 Ponds

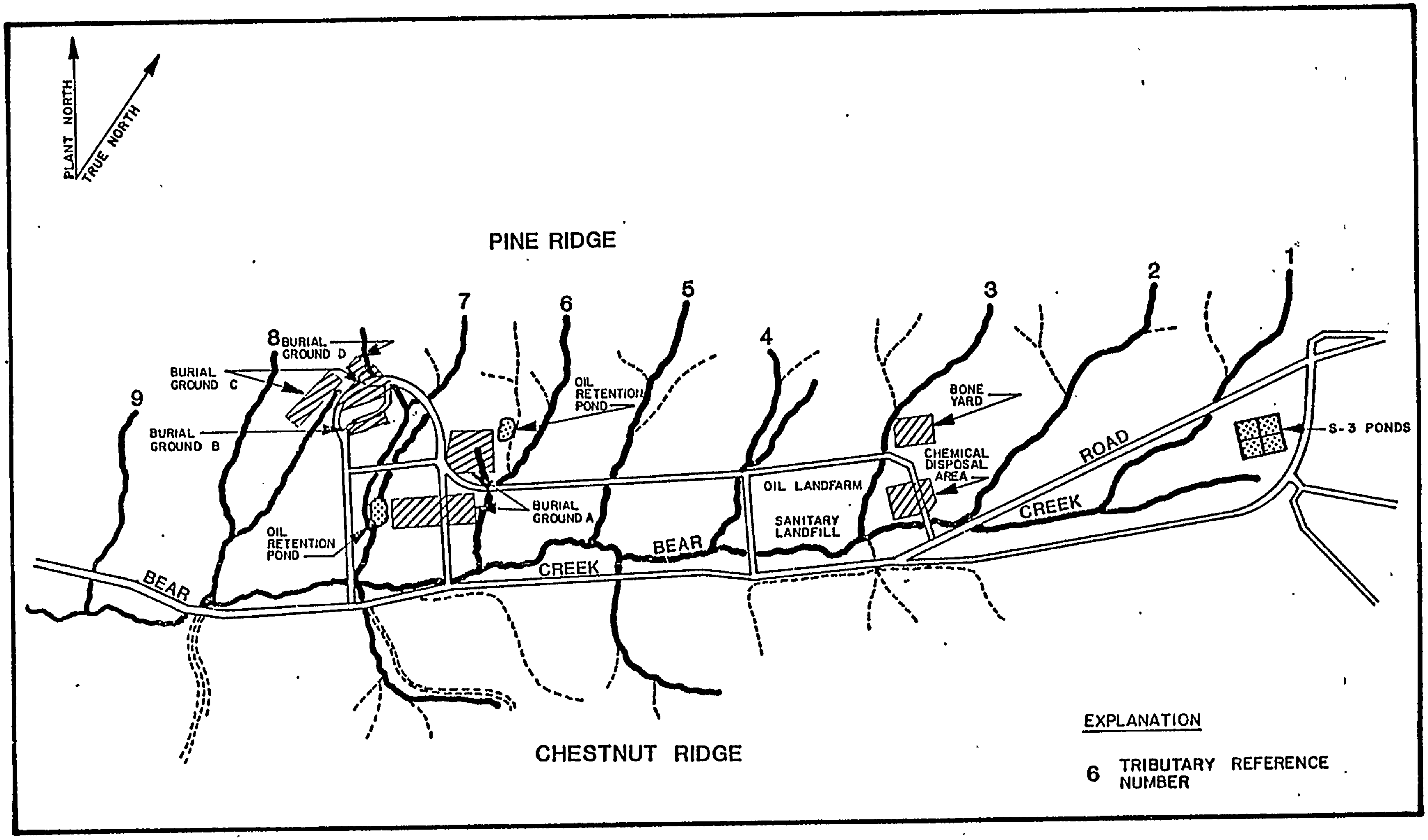


Figure 2-2. Waste-Disposal Areas and Drainage Features.

Fork Poplar Creek about seven miles downstream from its headwaters. Along most of its course, Bear Creek occupies the southern part of the valley adjacent to Chestnut Ridge. Several small tributaries flow southward from the base of Pine Ridge into Bear Creek, in close proximity to the various waste disposal sites.

The original methods of waste disposal in the Bear Creek Burial Grounds were backfilling of excavated trenches with waste materials, pouring of liquids into standpipes, and applying liquid wastes directly on the land surface. Contaminants generated from the wastes have moved into the surface water and ground-water systems. The constituents in the contaminated waters include oils and coolants, uranium, solvents, heavy metals, and nitrates.

In recent years, the Y-12 Plant has taken steps to control run-on and runoff of surface waters and soils from the disposal areas, including emplacement of native soil caps and implementation of erosion-control measures. Since 1950, approximately 135 test wells and exploration holes have been drilled in the valley to monitor ground-water flow and subsurface transport of contaminants. This drilling program has provided a large amount of technical information on the hydrogeologic system and the extent of contamination of ground water in the vicinity of the Bear Creek Burial Ground waste disposal areas. The drilling program is being continued and will be expanded during the coming year to fill data gaps revealed by the initial exploratory program.

2.3 OBJECTIVES AND SCOPE OF STUDY

This report, prepared for DOE by Martin Marietta Energy Systems, Inc., with the assistance of Geraghty & Miller, Inc., consulting ground-water hydrologists, presents a series of options for remedying contamination in the Bear Creek Watershed resulting from past waste disposal practices. The report is based on data compiled and interpreted through April 1984. The report discusses the waste disposal areas, the hydrologic system of the valley, the evidence for contamination of water and soils, remedial steps that appear to offer the greatest promise of abating the contamination, and the program of work to be accomplished before the most effective remedy can be selected and its effects monitored.

For reasons explained later in the report, a final remedial plan cannot be adopted at this time, mainly because the full extent of the contamination is not known and the volumes of surface water and ground water that might have to be treated have not been determined. Also, because the objective is to restore and protect water quality, negotiations will be necessary with TDHE and EPA to establish the water-quality standards to be achieved and the points of compliance at which these standards will be enforced.

The ultimate objective of the on-going program is to work toward restoration of the quality of water in Bear Creek in the interest of improving the recovery of biotic communities and upgrading the water quality of the stream. The specific water-quality standards to be achieved cannot be established until several ecological and water-quality studies are completed.

The Y-12 Plant has developed a schedule for performing these additional studies with an objective of establishing a final set of remedial options in a report to be submitted to TDHE and EPA in mid-CY-1985. In the meantime, the on-going investigations will establish (1) the patterns of transport of contaminants through water and soil, (2) the potential for further impacts stemming from the contamination, (3) the program for long-range monitoring of the environment, and (4) the design for and anticipated effectiveness of the final recommended remedial plan.

3.0 WASTE DISPOSAL AREAS

3.1 OVERVIEW

The evaluations presented in this report are limited to two of the three principal disposal areas in Bear Creek Watershed, namely the burial grounds and the oil landfarm. As part of the evaluation, H&R Technical Associates, Inc., (Oak Ridge, Tennessee) reviewed data compilations that established where major categories of waste had been deposited in these disposal areas. Table 3-1 lists the types of wastes deposited in those two disposal areas. The principal categories of wastes are heavy metals, oils and coolants, salts, debris, solvents, EDTA (ethylene diaminetetracetic acid), asbestos, and material contaminated with radioisotopes.

H&R Technical Associates also evaluated differences in the compatibility of the wastes at the burial grounds (see Appendix A). H&R concluded that since the wastes are of very different chemical compositions, special remedial actions may have to be considered in order to deal with the contaminants.

3.2 BURIAL GROUNDS

This disposal area consists of several separate sites, namely Burial Grounds A, B, C, and D, and two oil retention ponds. The first disposal trench in the burial grounds was excavated in August 1955; data on the exact dimensions of the trenches are unavailable. The trenches are believed to be between 14 and 25 feet deep. Solid wastes, and at various periods oils and coolants, from the Y-12 Plant were disposed of in these facilities. Burial Ground B was opened in 1962 for the disposal of depleted uranium metal and oxides. Burial Ground C was opened in 1962 for the disposal of beryllium,

TABLE 3-1. SUMMARY OF WASTE MATERIALS DEPOSITED IN THE BURIAL GROUNDS AND THE OIL LANDFARM

Constituent	Burial Grounds A	B	C	D	Walk-In Pits	Oil Landfarm
Heavy Metals (4)	P	P	P	P	P	ID
Oils & Coolants	P	P	P	P	P	P
Salts	P	NI	P	NI	P	ID
Debris	P	NI	P	NI	P	NI
Solvents	P	NI	P	NI	NI	ID
EDTA	P (1)	NI	NI	NI	P	ID
Asbestos	P (2)	NI	P	NI	P	NI
Material Contaminated With Radioisotopes	P	P	P	NI	P (3)	ID

Note:

P Means the constituent was listed in the records as having been deposited in the area;

NI Means the constituent was not identified in the records as having been deposited in the area;

ID Means that the records contain insufficient data; and

(1) In A-South only

(2) In A-North only

(3) In northern walk-in pit only

(4) Includes beryllium

beryllium oxide, thorium, and solid waste contaminated with these materials. Enriched uranium contaminated materials were disposed of in Burial Ground C. Burial Ground D was used after 1968 for the disposal of some depleted uranium metals and oxide after Burial Ground B had reached capacity. The Walk-In-Pits were used from 1966 to 1981 for the disposal of chemicals and uranium metal saw fines.

In July 1959, the Y-12 Plant started to dispose of mop waters in Burial Ground A. Between 1961 and 1971, waste oils and coolants also were disposed of at this site. In 1979, the disposal of mop waters in Burial Ground A was terminated.

Two oil retention ponds were constructed at the burial grounds after liquids were observed seeping from the ends of some of the trenches. Pond 1 was constructed in 1971 in the southwest corner of Burial Ground A, and Pond 2 was constructed in 1972 in the northeast corner of Burial Ground A. In 1974 and 1975, oil was skimmed from the ponds and spread at the oil landfarm or sprayed onto nearby trees for control of Pine Bark Beetles. Oil accumulations were not observed in Pond 2 after 1975. Prior to 1979, waste oils and coolants were not specifically analyzed for contaminants before application to the oil landfarm. In 1979, analytical results for oil samples collected from the surface of the ponds indicated the presence of PCBs. Thereafter, oils were analyzed for uranium, beryllium, thorium, and PCBs.

3.3 OIL LANDFARM

During 1972, a study was undertaken with the Oak Ridge National Laboratory to determine whether a process using natural soil microbial assimilatory processes to slowly degrade oily wastes could be used at the Y-12 Plant. The process involved application of waste oils and coolants to nutrient adjusted soils followed by frequent soil cultivation to maintain aerobic conditions. The area selected for the program was designated as the Y-12 Plant Oil Landfarm.

As a result of development activities in 1972, a field site was selected early in 1973 for the oil landfarm. The site selected is located north of the Y-12 Centralized Sanitary Landfill I in Bear Creek Valley. Initially, the facility consisted of 1.3 acres of land (six plots excluding roadways) prepared for application of waste oils and coolants. The facility size gradually increased to 4.0 acres (24 plots excluding roadways) in 1979 to accommodate increased waste oil and coolant generation rates.

Beginning in May 1973, wastes were collected in tank trucks, distributed over the surface of the plots, and cultivated into the top three inches of soil. The plots were cultivated frequently between application periods. The application dates were selected to minimize precedent rainfall and forecasted antecedent rainfall events. The oil landfarm was operated on a seasonal basis from April to October to permit favorable conditions for soil microbial activity. The application of waste liquids in the oil landfarm plots was terminated in October 1982. As noted previously, the waste oils and coolants spread on the oil landfarm plots were not analyzed for contaminants prior to 1979.

4.0 HYDROLOGIC SYSTEM

4.1 WATERSHED HYDROLOGY

The Y-12 Plant is located in the Bear Creek Drainage Basin, which covers 7.4 square miles and flows into the East Fork Poplar Creek. The plant is in the upper part of the basin where elevations range from about 900 feet MSL (mean sea level) to about 1,200 feet MSL; the elevation of Bear Creek at its mouth is 755 feet MSL.

Several tributaries flow through the waste disposal areas into Bear Creek. These tributaries have been numbered (see Figure 4-1), beginning with tributary 1 at the headwaters of Bear Creek near the S-3 ponds and ending with tributary 9 downstream of the burial grounds. The total area of the Bear Creek Watershed above the point where it crosses the county line, slightly downstream of tributary 8, is 1.57 square miles. The U.S. Geological Survey has a partial record of streamflow at a gaging station designated as "Bear Creek at County Line near Oak Ridge." Average flow at that point is estimated at 2.7 cfs (cubic feet per second) or about 1,200 gpm (gallons per minute). Precipitation at the Oak Ridge gaging station is approximately 55 inches per year, and evapotranspiration is about 30 inches or 55 percent of precipitation.

In March 1984, a streamflow measurement program was implemented along Bear Creek at 12 separate stations (locations shown on Figure 4-1). The objectives of this program are to:

- o Characterize the average streamflow in Bear Creek and its tributaries;

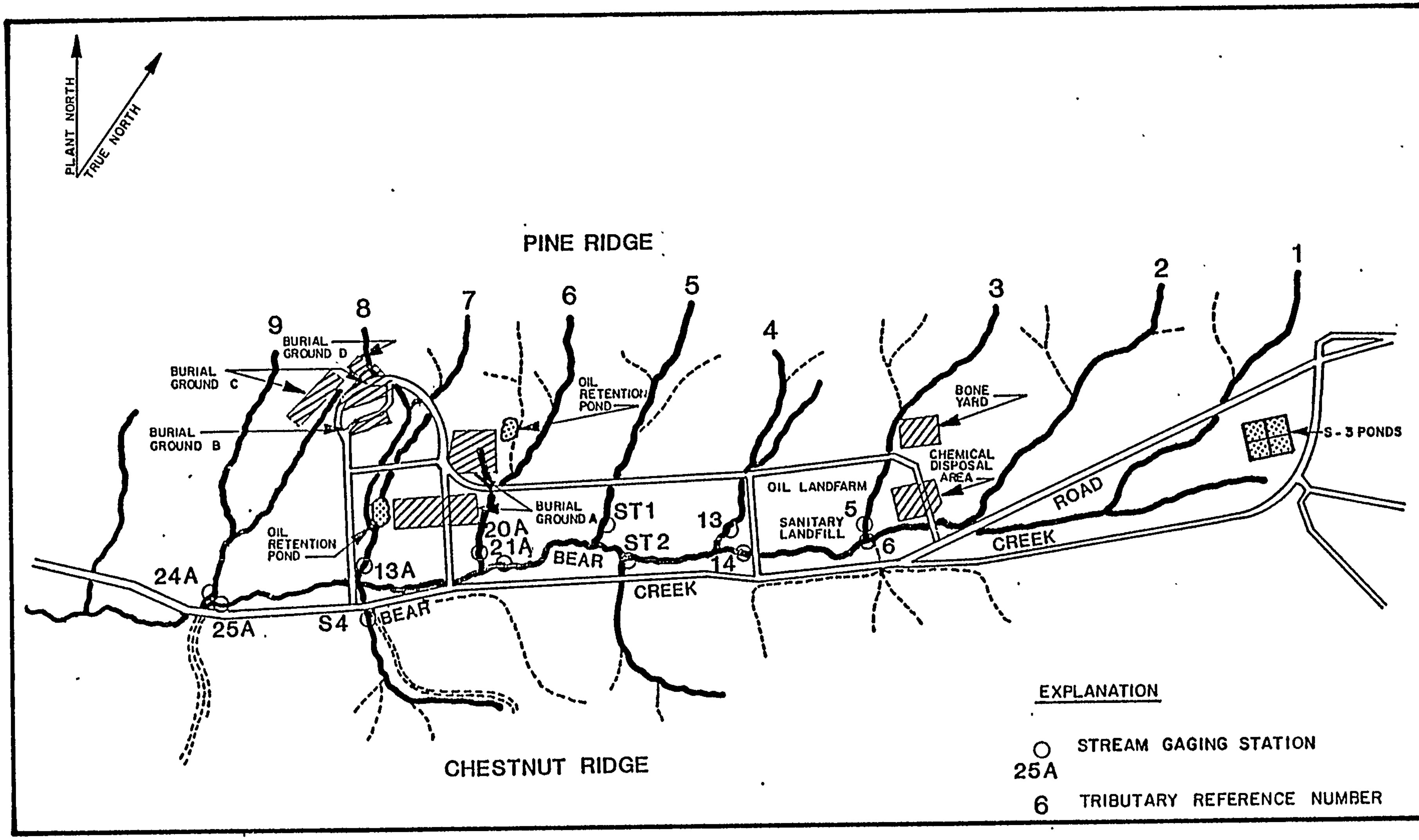


Figure 4-1. Stream Gaging Stations.

- o Begin a historical record from which expected high and low flows can be predicted;
- o Determine baseflow, which will be used in calculating the water budget for the area;
- o Characterize the surface-water/ground-water interactions along the stream;
- o Evaluate seasonal fluctuations in streamflow; and
- o Compare the flow contributed to Bear Creek from the south with the flow contributed from the north.

The results of the program thus far indicate that Bear Creek in some sections loses water to the ground-water system (a losing stream) and in other sections gains water from the ground-water system (a gaining stream). The relationship between surface flow and subsurface flow is important in mass-balance calculations, and it is expected that the information to be derived from this program will be useful in tracking the possible migration of contaminants through the hydrologic system. Additional data will be used to calculate a water budget for the project site that will describe the hydrologic regime of the watershed by quantifying the components, i.e., precipitation, evapotranspiration, streamflow, recharge to ground water, and changes in storage in the various parts of the hydrologic system.

Quantification of the hydrologic components is important in the selection and design of remedial action alternatives. For example, long-term data on streamflow would be needed to determine the design capacity of a treatment plant that might be installed on Bear Creek. Also, minimum baseflow requirements would have to be established in order to design the rates of pumping from systems of interceptor wells.

No site-specific data on precipitation or evapotranspiration have been collected within the waste disposal areas. The recharge to ground water is derived primarily from precipitation; there also is some evidence, as noted previously, that in some sections Bear Creek is a losing stream and therefore helps to recharge the aquifer in parts of the valley. Ground-water recharge will be quantified as additional data become available on climate, streamflow, and fluctuations of water levels in wells.

4.2 GEOLOGIC FRAMEWORK

A geologic section through Bear Creek Valley is shown in Figure 4-2. As indicated, the bordering ridges, Pine Ridge and Chestnut Ridge, are formed by the sandstones of the Rome Formation and dolomite of the Knox Group, respectively. The valley is underlain by shales and limestones of the Conasauga Group. These formations represent folded and overthrust blocks; the stratigraphic sequence is repeated to the northwest and southeast, in similar thrust blocks that are separated by faults. In Bear Creek Valley, the formations strike N60E; dips are southeasterly, commonly at 20 to 50 degrees SE.

The Rome Formation consists of sandstone, with minor amounts of siltstone and shale. The formations of the overlying Conasauga Group are thin-bedded and laminated shales, siltstones, sandstones, calcareous shales, and limestone. Limestone and interbedded shales of the Maynardville Limestone, the uppermost member of the Conasauga Group, are the dominant lithology along Bear Creek and on the southeastern side of the valley, where they are in contact with dolomite of the Knox Group.

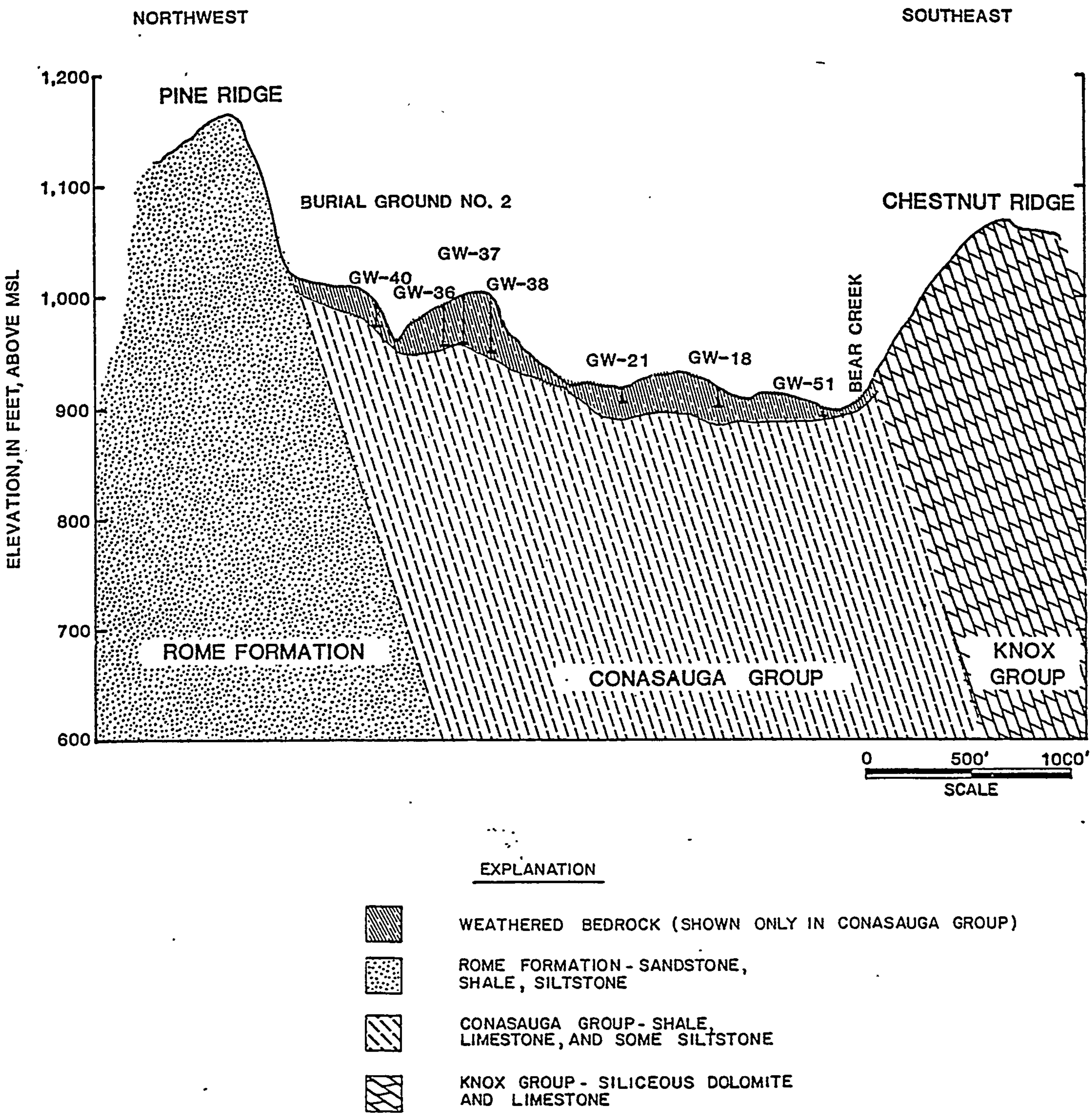


Figure 4-2. Generalized Geologic Cross-Section of the Bear Creek Valley.

These units are overlain by a zone of weathered bedrock varying in thickness from about 50 feet to less than 10 feet; weathered rock generally is thickest in the areas of high ground and thin near tributary creeks. A few feet of alluvial silty clay is commonly present in tributary channels and along Bear Creek. In some test borings to the north of Bear Creek, silt with chert and limestone pebbles was logged to a depth of 19.5 feet, which may represent older alluvium in a former channel of Bear Creek.

4.3 GROUND-WATER REGIME

Ground water, derived from the infiltration of precipitation into the low-permeability residual soils and weathered bedrock, occurs at relatively shallow depths throughout the valley. The configuration of the water table conforms closely to the topography. Water-table contours for the burial grounds and oil landfarm are shown in Figures 4-3 and 4-4, respectively. As indicated, the water table slopes from elevations of about 1,000 feet MSL toward Bear Creek, with components of flow toward the tributaries. Gradients are steepest near the base of Pine Ridge, about 80 feet/1,000 feet, and flatten to about one half of that value near Bear Creek. In some wells close to Bear Creek, water levels reportedly are lower than the creek. In general, ground water discharges toward the tributary creeks.

The water-level contours are based on measurements in shallow monitoring wells penetrating weathered or partially weathered bedrock to depths of about 20 to 50 feet. The formations, predominantly shales with thin interbeds of siltstone, sandstone, and limestone, have weathered differentially and are highly fractured and jointed. In addition to the north-trending joints,

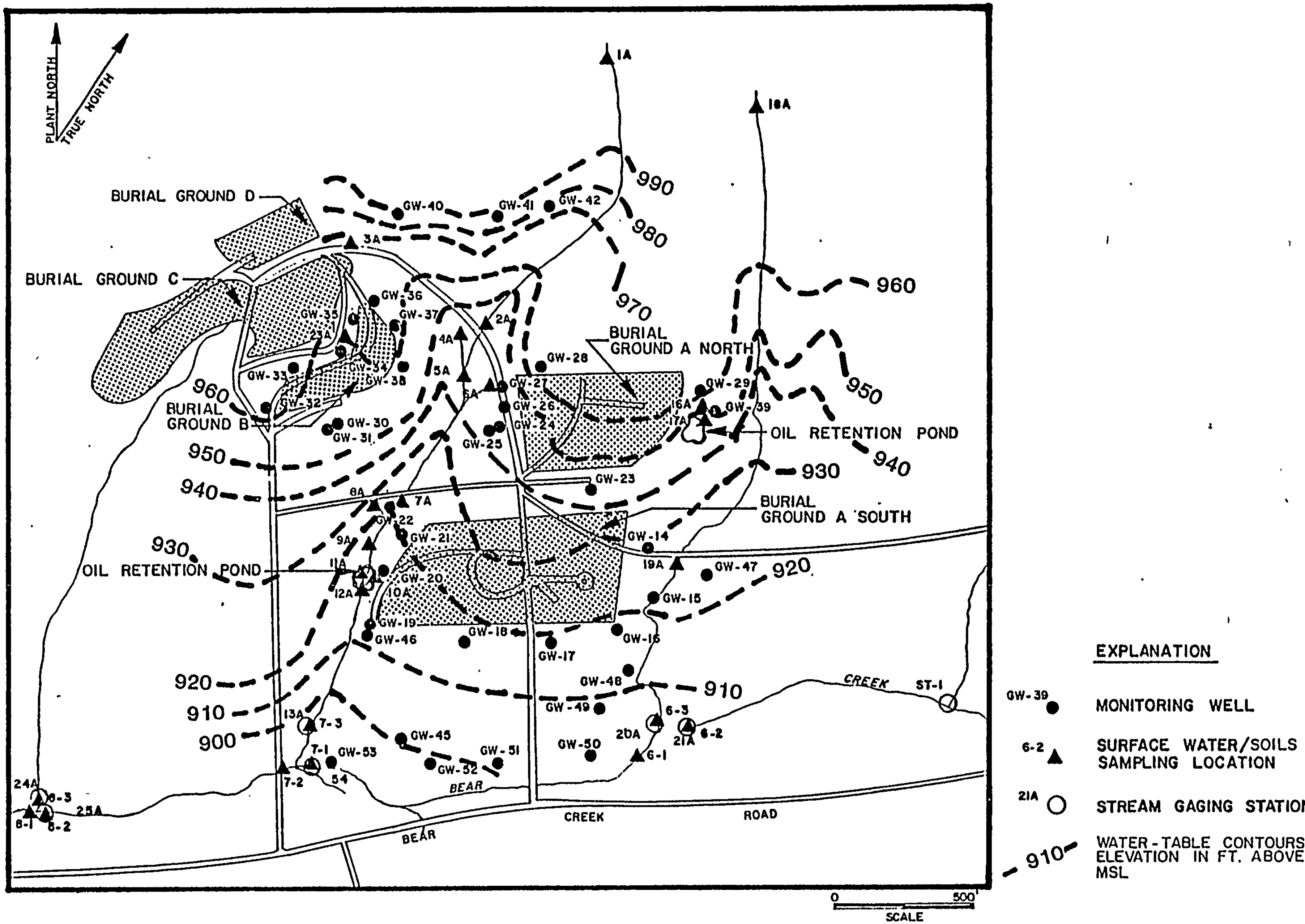


Figure 4-3. Water-Table Configuration at the Burial Grounds, March 1984.

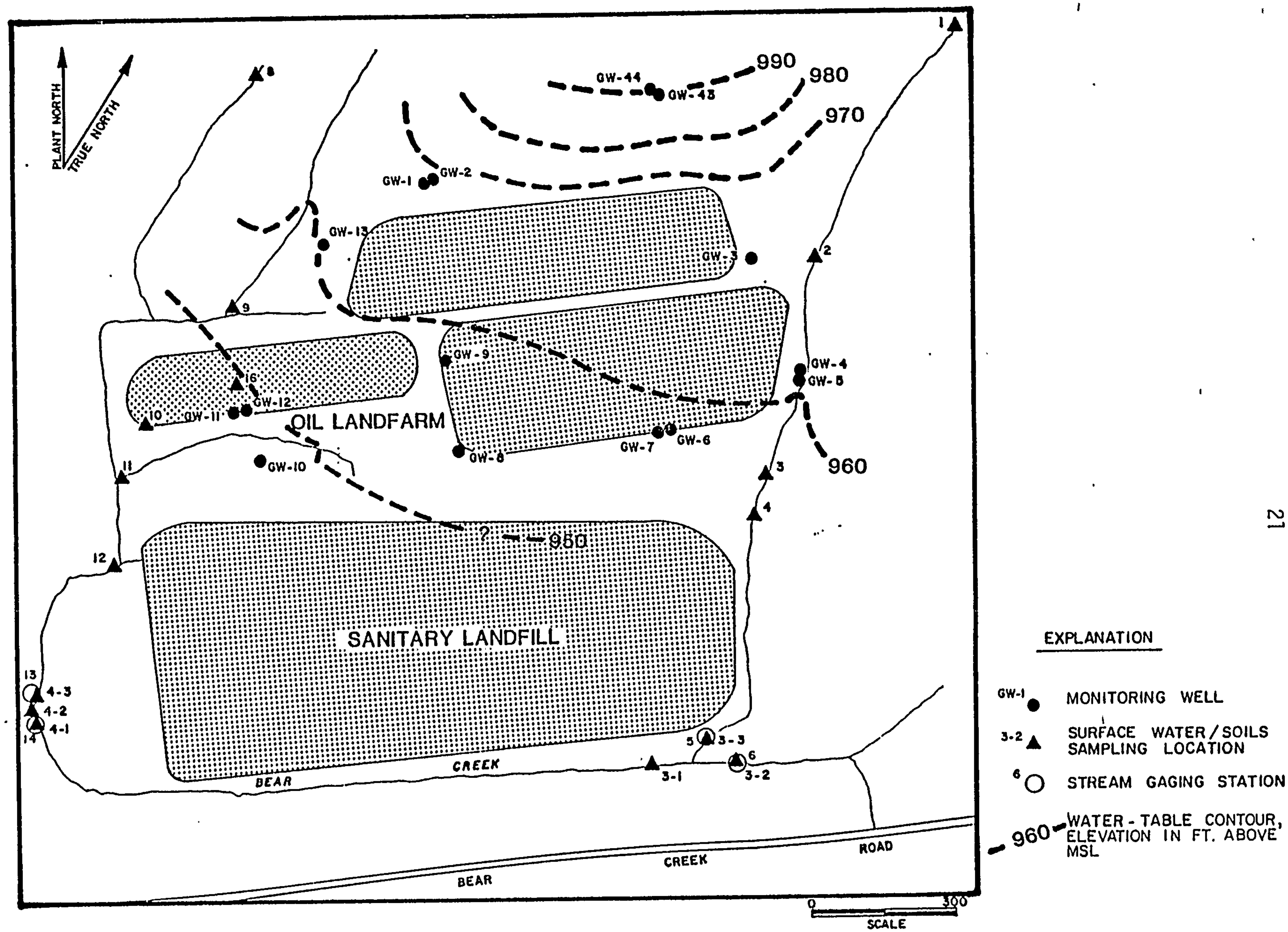


Figure 4-4. Water-Table Configuration at the Oil Landfarm, March 1984.

manifest in the parallel alignment of the northern tributaries, bedding-plane partings and highly variable joint and fracture systems, ranging from near vertical to horizontal, have been revealed in core samples. The aquifer materials display a significant degree of anisotrophy, but nevertheless, the water-level contours are believed to be representative of patterns of ground-water flow at least in the very shallowest part of the aquifer.

Field permeabilities determined by slug or packer tests in the monitoring wells indicate that most values vary within relatively small limits (1 x 10^{-5} to 1 x 10^{-4} cm/sec) and that there is no general decrease in permeability with depth within the tested interval. The highest permeabilities, about 1 to 3 x 10^{-3} cm/sec, were determined in highly fractured shales and interbedded thin sandstone, silts, and limestone.

Permeabilities determined in a 1983 pumping test conducted within the Burial Ground area are of a similar magnitude, ranging from 5 x 10^{-5} to 1.3 x 10^{-3} cm/sec, and averaging 4.7 x 10^{-4} cm/sec. Assuming an average permeability of 5 x 10^{-4} cm/sec, a gradient of 40/1,000, and an effective porosity of 20 percent, shallow ground-water flow would be at rates of about 100 ft/yr. Locally, hydraulic gradients are two or three times steeper and permeabilities may be considerably lower or higher than the assumed average.

Deeper wells (50 to 70 feet) in the valley indicate upward components of flow, with some water levels close to or above land surface. Virtually no information, however, is available concerning ground-water occurrence and flow at depths greater than about 150 feet. It can only be surmised that deep ground-water flow may be controlled by alternating relatively permeable and impermeable inclined strata and by solution features in the limestones adjacent to and south of Bear Creek. Detailed hydrogeologic investigations conducted in the Conasauga Group in Melton Valley, a geologically similar setting, will be evaluated to determine if data indicating no deep ground-water movement at the site are applicable to Bear Creek Valley.

5.0 WATER AND SOIL CONTAMINATION

5.1 GENERATION OF LEACHATE

In Bear Creek Valley, a wide variety of waste materials have been deposited (see chapter 3.0), each with a different potential for generating contaminants that could be discharged into the environment. Basically, the generation of the contaminants (production of leachates) is related to the solubility of individual waste components; Table 5-1 shows the theoretical solubility of prominent organic compounds known to be present in the waste sources. The table does not provide a direct clue as to the composition of any particular leachate, partly because the presence of one contaminant in the leachate may alter the mobility of other contaminants and partly because the geologic environment itself may attenuate the contaminants differentially. As an example, relatively insoluble oils and PCBs may become mobilized by the presence of solvents, one of the principal wastes disposed of in the valley.

The two major routes of contaminant migration are: (1) via surface water and ground water, and (2) via erosion and transport of contaminated soil. Contaminants in surface water can move over long distances in a relatively short period of time.

Partly offsetting the transport of contaminants in ground water is the capacity of some soils to adsorb at least part of the contaminant load through cation-exchange and reactions with natural organic matter in the soils. Individual metals, for example, have different affinities for cation-exchange on soils. However, this phenomenon is complicated by the capacities of other metal ions to compete for cation-exchange sites on the soil particles.

TABLE 5-1. THEORETICAL SOLUBILITIES OF SELECTED ORGANIC COMPOUNDS

Compound	Water Solubility at 20-25 °C (mg/l)
Benzene	1,800
Toluene	540
Methylene Chloride	16,700
1,1 dichloroethane	5,500
trans 1,2-dichloroethylene	6,300
vinyl chloride*	1.1
chloroethane	5,740
1,1,1-trichloroethane	950
trichloroethylene	1,100
tetrachloroethylene	150
trichlorofluoromethane	1,100
bis(2-ethylhexyl)phthalate	0.4
PCB (1242)	0.24
PCB (1260)	0.0027

* Because of its high volatility, vinyl chloride can migrate in the vapor phase. Its low solubility should not be considered as an indication of low mobility.

Transport of an organic compound, on the other hand, depends primarily on the solubility of the compound, its potential for biological or chemical degradation, and the organic matter content of the soils.

Biodegradation operates to different degrees on different organic compounds, with PCBs being highly resistant to such degradation. Efficient biodegradation depends on the availability of other nutrients and on a non-toxic environment where microbial populations can multiply. The presence of several daughter products of such solvents as carbon tetrachloride, tetrachloroethylene, and trichloroethane suggests that at least some bacteriological action takes place.

Based on the evaluations performed thus far at the disposal sites, the wastes have been grouped into several general categories mainly on the basis of their solubility and density. Some of the waste materials, for example, are essentially soluble in water (mostly the inorganic compounds). Others have limited solubility (oils, solvents, and PCBs) while still others are lighter than water (oils) or heavier than water (some solvents). Comparison of the inherent properties of these categories of wastes with their observed low concentrations in waters strongly suggests that cation-exchange is highly effective in attenuating the materials if they move through the ground.

In the final analysis, regardless of the volume, composition, solubility, or cation-exchange capacity of the different wastes, the transport of contaminants through the hydrologic system is best measured by direct sampling and analysis of waters in the streams and observation wells. The information developed for Bear Creek Valley shows that certain volatile organic compounds (VOCs) are prominent in many of the samples of soil and water, along with elevated concentrations of certain metals, and these are considered as primary indicators of the extent of the contamination. The following sections address the overall problem from this viewpoint, with the principal emphasis on direct monitoring of contaminant transport.

5.2 SURFACE WATER CONTAMINATION

Information on contamination of water in Bear Creek and its tributaries is very limited and is based mainly on one set of samples collected in late 1983 and on a preliminary evaluation of a second round of samples collected in March 1984 (Appendix B). Figure 5-1 shows the summed concentrations (in ppb) of VOCs in Bear Creek in March 1984. It should be noted that the concentrations of individual VOCs reported in Appendix B do not necessarily add up to the total concentration of VOCs, because all individual components either have not been identified or not quantified.

Generally, the concentrations of VOCs increase in a downstream direction. However, at some of the intermediate surface water sampling stations, the concentration of VOCs is greater than at stations upstream or downstream, suggesting localized inputs or outputs. Additional investigations (see Chapter 8.0) are planned to provide a clearer picture of transport of contaminants via the surface water route.

Surface water runoff across the waste disposal sites probably picks up some contaminants for transport into the tributaries and into Bear Creek itself. Factors affecting this process include local variations in topography, soil permeabilities, soil moisture, and the intensity of the precipitation. In addition, ground waters (see Section 5.3) enter the

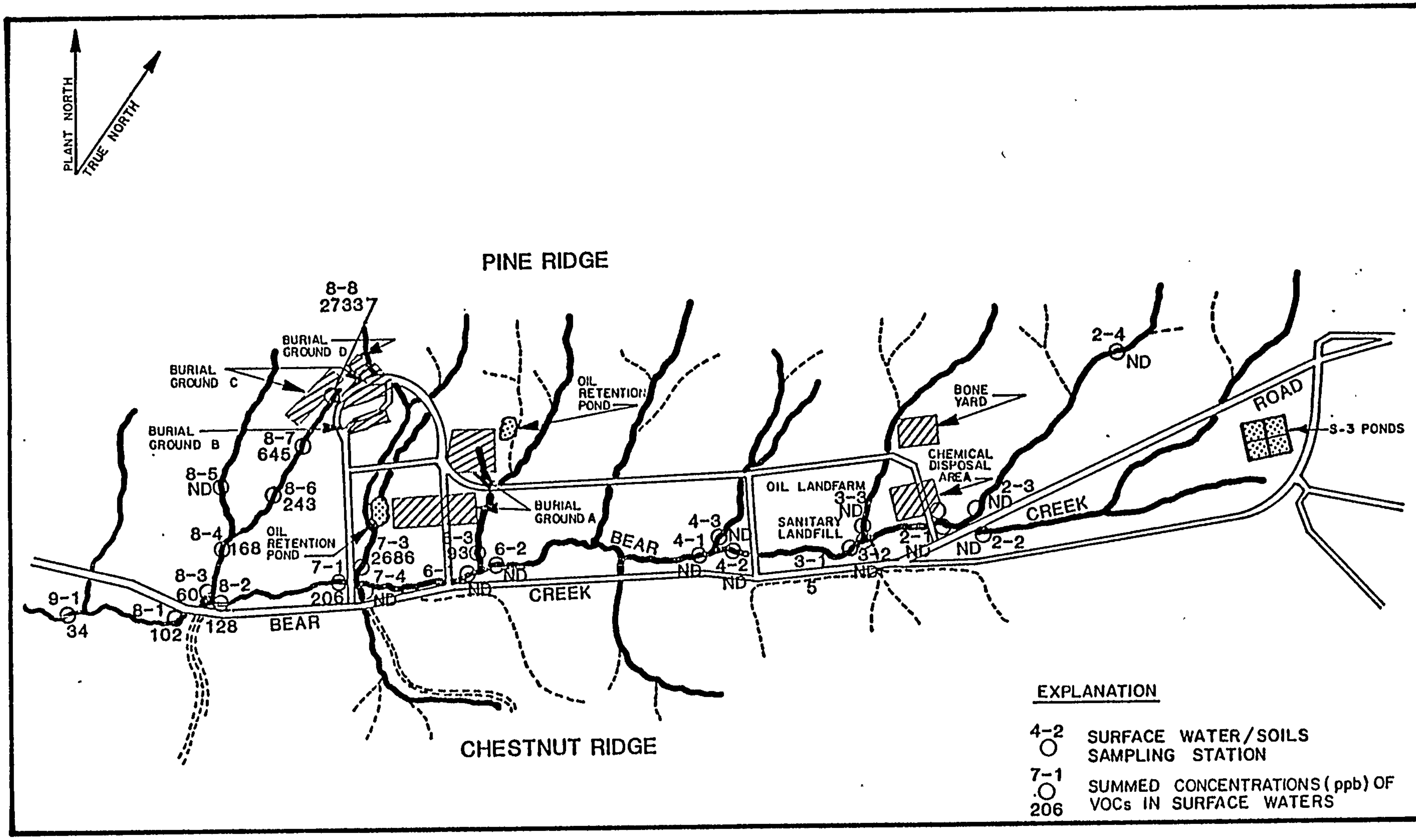
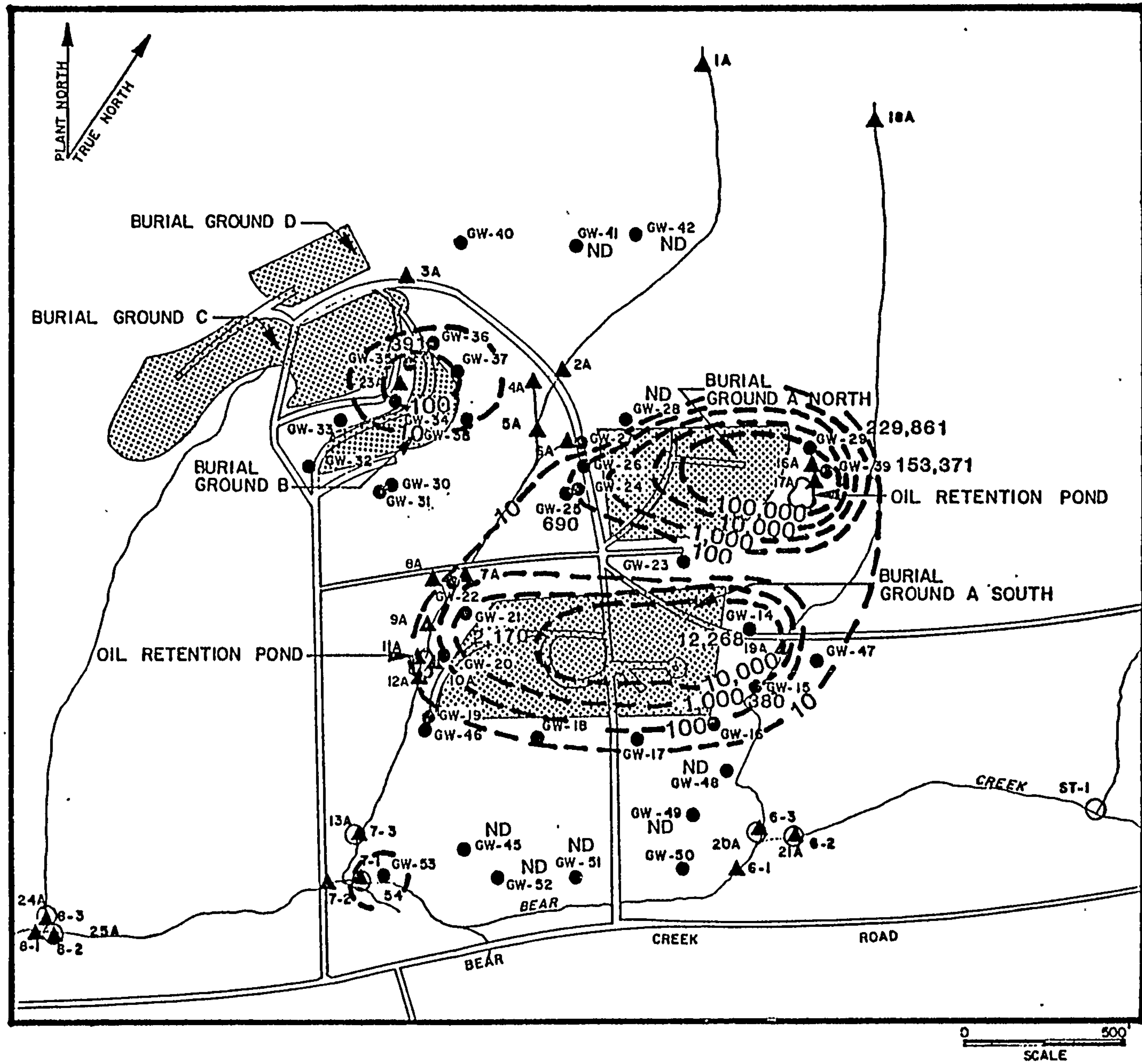


Figure 5-1. Summed Concentrations (ppb) of VOCs in Water Samples From Bear Creek and Its Tributaries, March 1984.



Note: Sample results from only shallow monitoring wells are shown.

EXPLANATION

GW-39 ● MONITORING WELL

6-2 ▲ SURFACE WATER/SOILS SAMPLING LOCATION

21A ○ STREAM GAGING STATION

GW-26 690 ● SUMMED CONCENTRATIONS (ppb) OF VOC's IN GROUND WATER

10 LINE OF EQUAL CONCENTRATIO

Figure 5-2. Summed Concentrations (ppb) of VOCs in Ground Water at the Burial Grounds, March 1984.

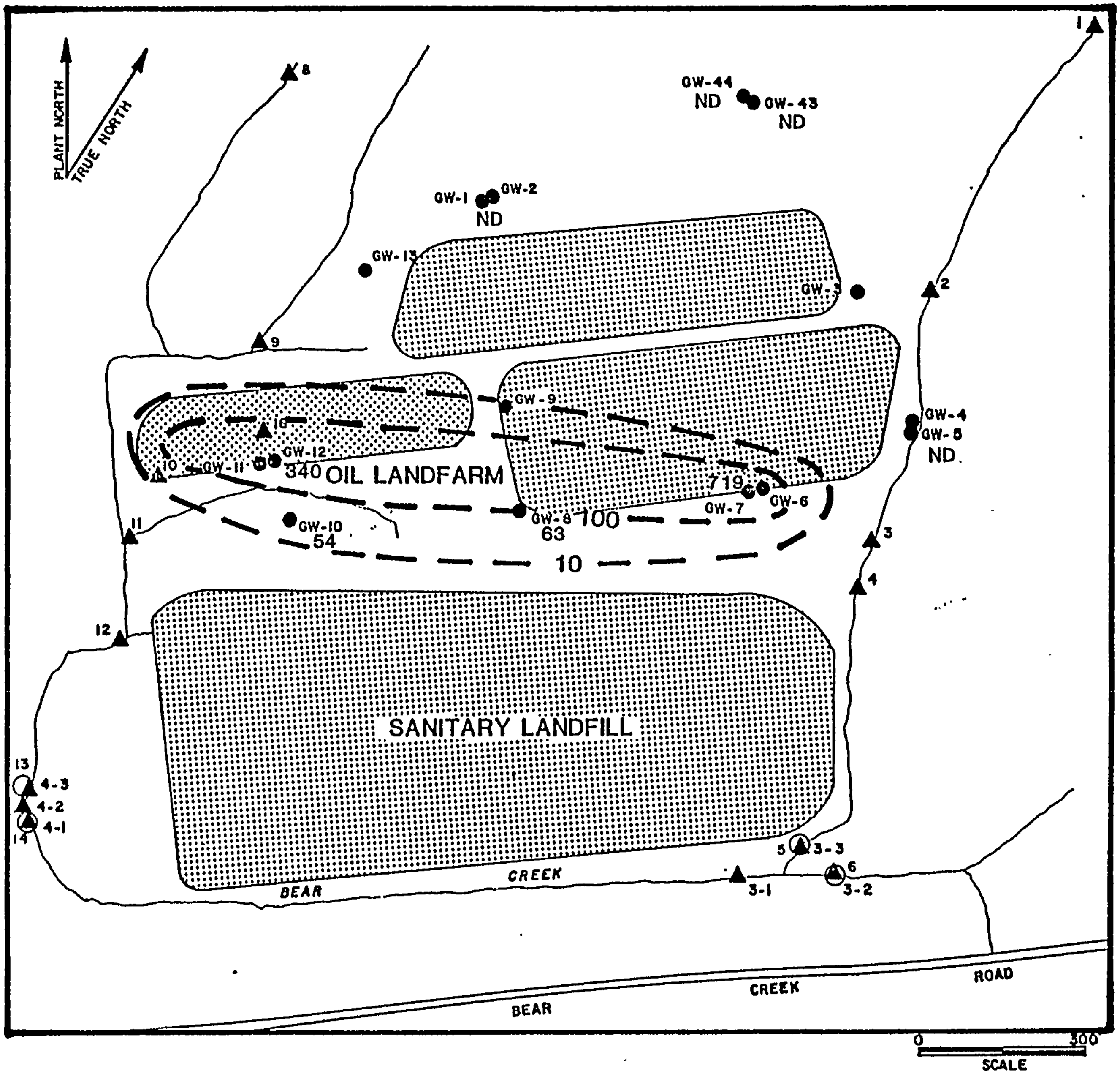
streams, potentially providing separate inputs of contaminants.

At this stage of the investigation, the data indicate that overland runoff, seepage of ground water, and transport of sediments all contribute contaminants to Bear Creek and its tributaries. It will be essential to better define these different mechanisms before an effective remedial action plan can be designed.

5.3 GROUND-WATER CONTAMINATION

An extensive evaluation was made of the water-quality data from the monitoring wells installed in Bear Creek Valley. Comparisons were made, for example, of the observed concentrations of individual heavy metals, VOCs, electrical conductivity, chemical oxygen demand, nitrogen, alkalinity, and other principal constituents at each of the waste sites. The data on ground-water quality used in this evaluation are presented in Appendix C.

The movement of contaminants in the shallow ground-water system away from individual waste sources is, to a large extent, toward the tributaries. This pattern of flow is attributed partly to the proximity of the tributaries, partly to the orientation of trenches parallel to Bear Creek, and partly to the anisotropy of the shallow geologic formations, that is to say, since the geologic layers do not have the same permeability in all directions, water tends to move more freely in one preferred direction. Figure 5-2, for example, shows the summed concentrations of VOCs in shallow ground water at the burial grounds, illustrating clearly that the plumes of affected ground water have elliptical shapes with the long axis more or less parallel to Bear Creek. The plumes of VOCs in the oil landfarm display the same orientation (Figure 5-3).



Note: Sample results from only shallow monitoring wells are shown.

EXPLANATION

GW-1 ● MONITORING WELL

3-2 ▲ SURFACE WATER / SOILS SAMPLING LOCATION

6 ○ STREAM GAGING STATION

GW-10 54 ● SUMMED CONCENTRATIONS (ppb) OF VOC's IN GROUND WATER

—10— LINE OF EQUAL CONCENTRATION

Figure 5-3. Summed Concentrations (ppb) of VOCs in Ground Water at the Oil Landfarm, March 1984.

The distribution of metals and other constituents in the ground water is very similar to the distribution of VOCs, with the same general elliptical orientation. Figures 5-4 and 5-5 show, for example, the patterns of contamination for the sum of seven metals (arsenic, barium, cadmium, chromium, lead, selenium, and silver) found in the burial grounds and oil landfarm, respectively.

The majority of the wells in the valley only penetrate about the upper 60 feet of the geologic formations. Consequently, most of the information on subsurface transport of contaminants applies only to those uppermost layers; very little is known about the patterns of deeper ground-water flow. Because some of the leachates contain constituents that are heavier than water, there is a distinct possibility that contaminants of this kind may have moved downward below the zone monitored by the wells. Preliminary water-quality information from deep wells, for example, suggests that VOCs may be present to depths of approximately 200 feet at the burial grounds. The on-going investigation (see Chapter 8.0) incorporates an extended drilling program to define ground-water flows and the presence of contaminants in the deeper zones of the ground-water system.

The relatively large springs near the base of Chestnut Ridge discharge ground water from unknown depths into Bear Creek. Preliminary information suggests that the nitrate content of water from some of the springs is high, which may partly represent contamination stemming from the S-3 ponds at the northeastern end of Bear Creek Valley.

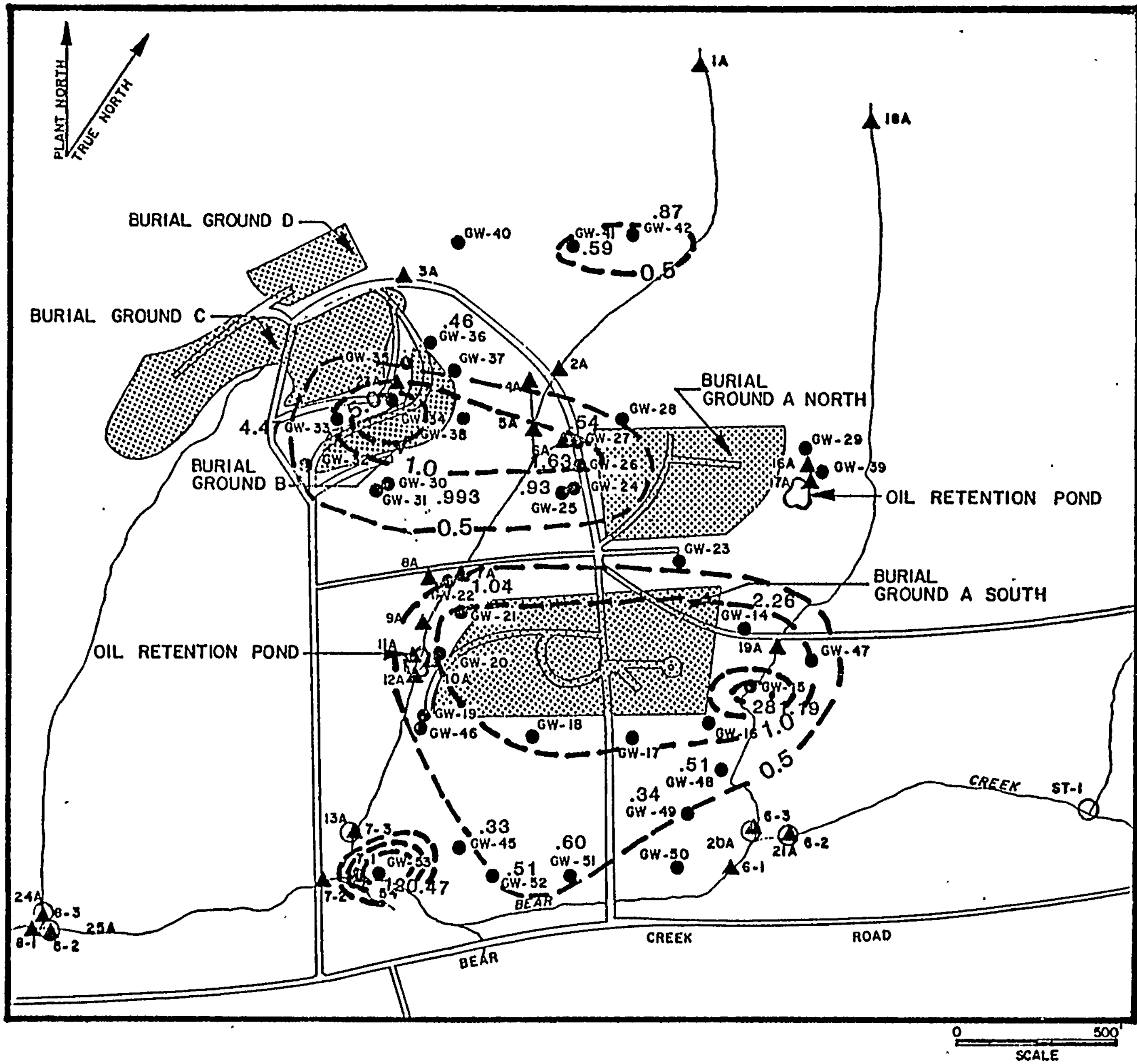


Figure 5-4. Summed Concentrations (ppm) of Selected Metals in Ground Water at the Burial Grounds, March 1984.

Note: Sample results from only shallow monitoring wells are shown.

EXPLANATION

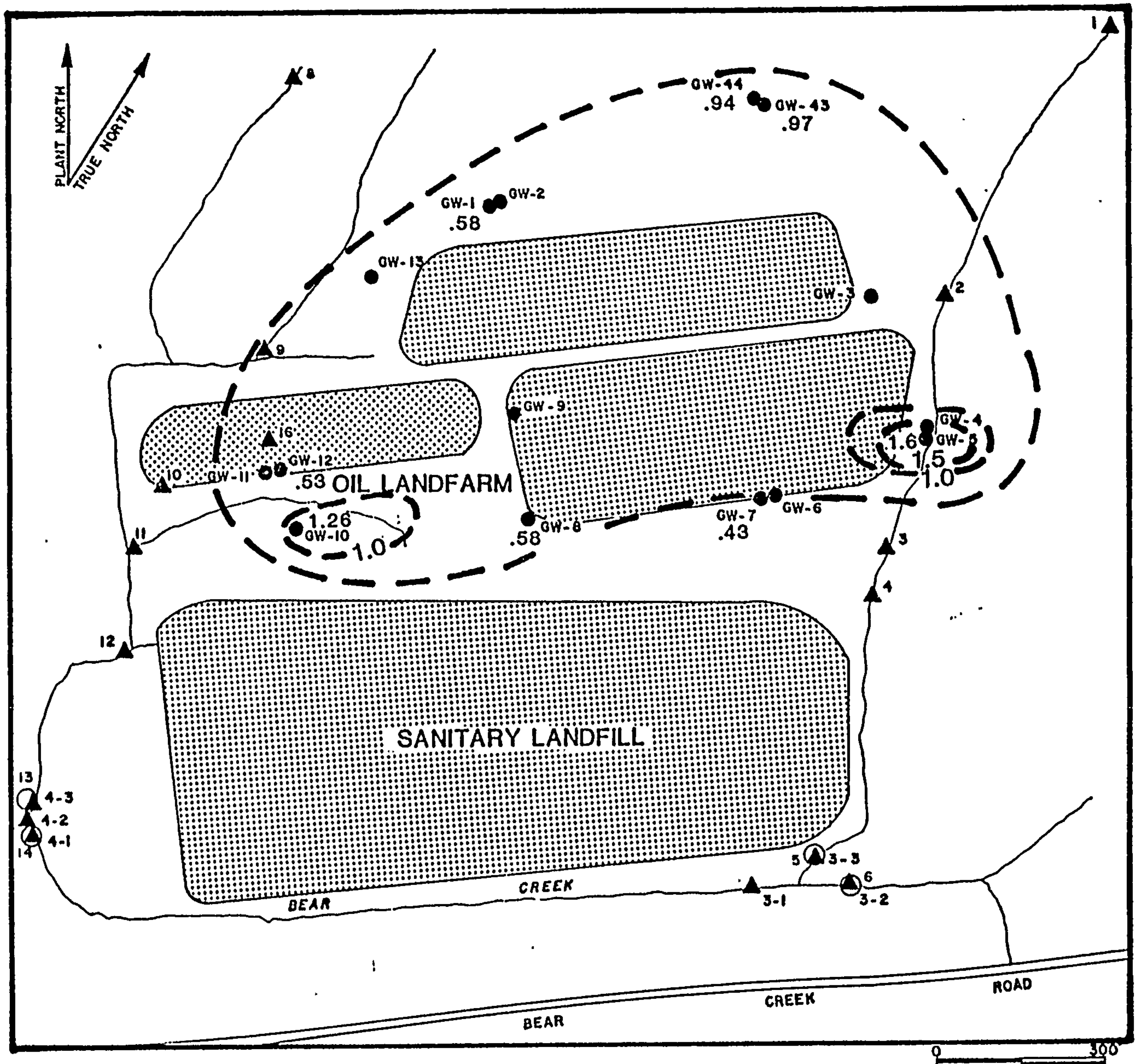
GW-39 ● MONITORING WELL

6-2 ▲ SURFACE WATER/SOILS SAMPLING LOCATION

21A ○ STREAM GAGING STATION

0.46 ○ GW-36 SUMMED CONCENTRATIONS (ppm) OF Ar, Ba, Cd, Cr, Pb, Se, AND Ag IN GROUND WATER

1.0 LINE OF EQUAL CONCENTRATION



Note: Sample results fro only shallow monitoring wells are shown.

Figure 5-5. Summed Concentrations (ppm) of Selected Metals in Ground Water at the Oil Landfarm, March 1984.

Logs of wells in the vicinity of Bear Creek provide evidence of solution cavities, which may be more or less interconnected, in the uppermost geologic units. If these openings prove to be more extensive in the valley, they may constitute a preferred pathway of ground-water flow, toward discharge points farther to the west.

5.4 SOILS CONTAMINATION

Soils on which contaminants have been adsorbed are present in the subsurface and in the beds of the tributaries of Bear Creek near the waste disposal sites. The summed concentrations of VOCs in soils in the burial grounds and in soils in the oil landfarm are shown in Figures 5-6 and 5-7, respectively. The extent and orientation of the patterns of contaminated soils correspond rather closely to the patterns of contaminated ground water shown in Figures 5-2 through 5-5. Appendix D contains data on soils contamination.

The relatively insoluble PCBs deposited in some of the waste sites have not resulted in any extensive contamination of soils at those locations. For the most part, PCBs have been identified in soils but only at places where PCB contaminated oils were deposited.

Contaminated soils have the potential for contaminating water if the chemistry of the water is altered so that remobilization of the contaminants can occur. Because contaminated soils in the tributary streams can be transported farther downstream, they may have to be contained or removed as part of the overall remedial program.

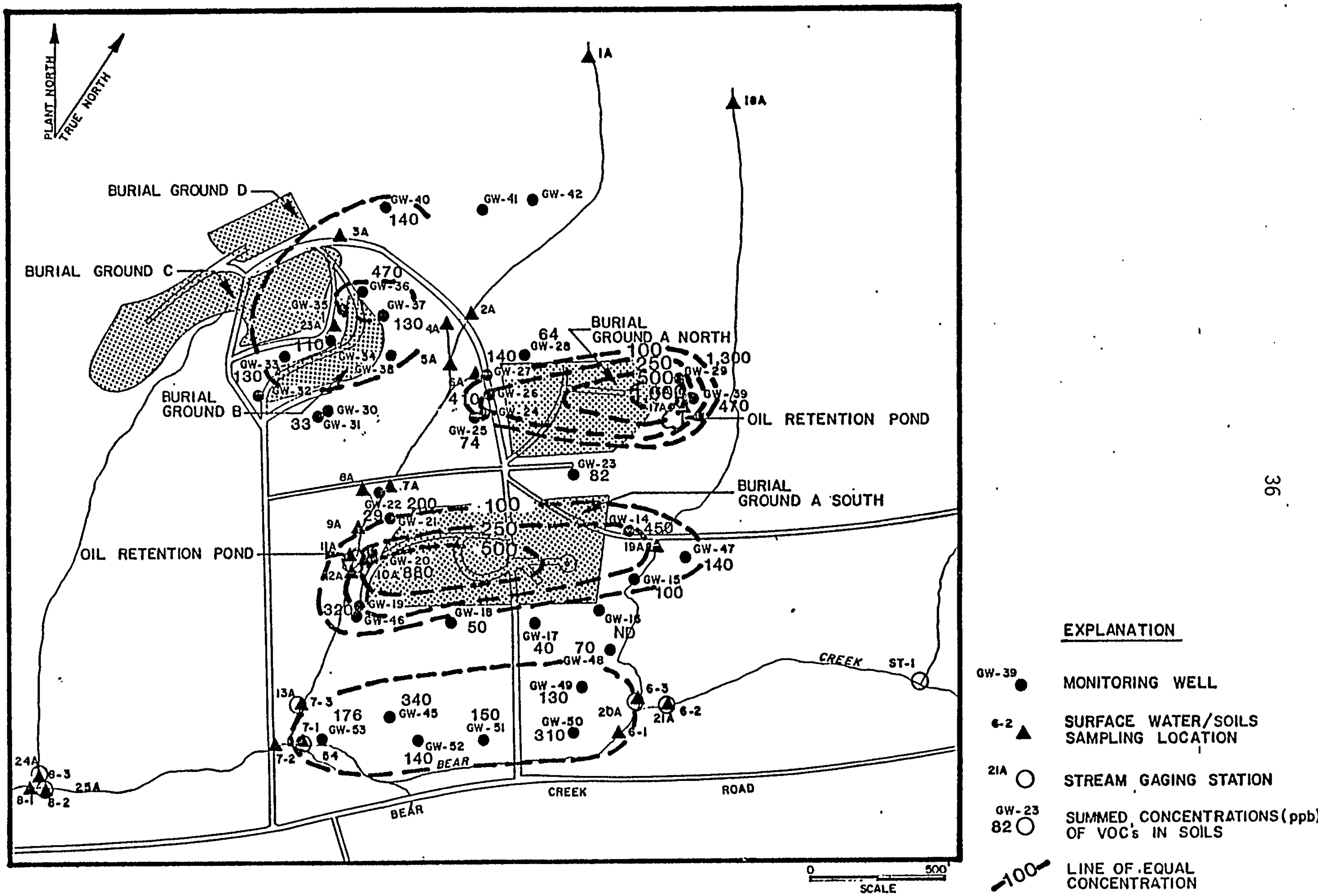


Figure 5-6. Summed Concentrations (ppb) of VOCs in Soils at the Burial Grounds, March 1984.

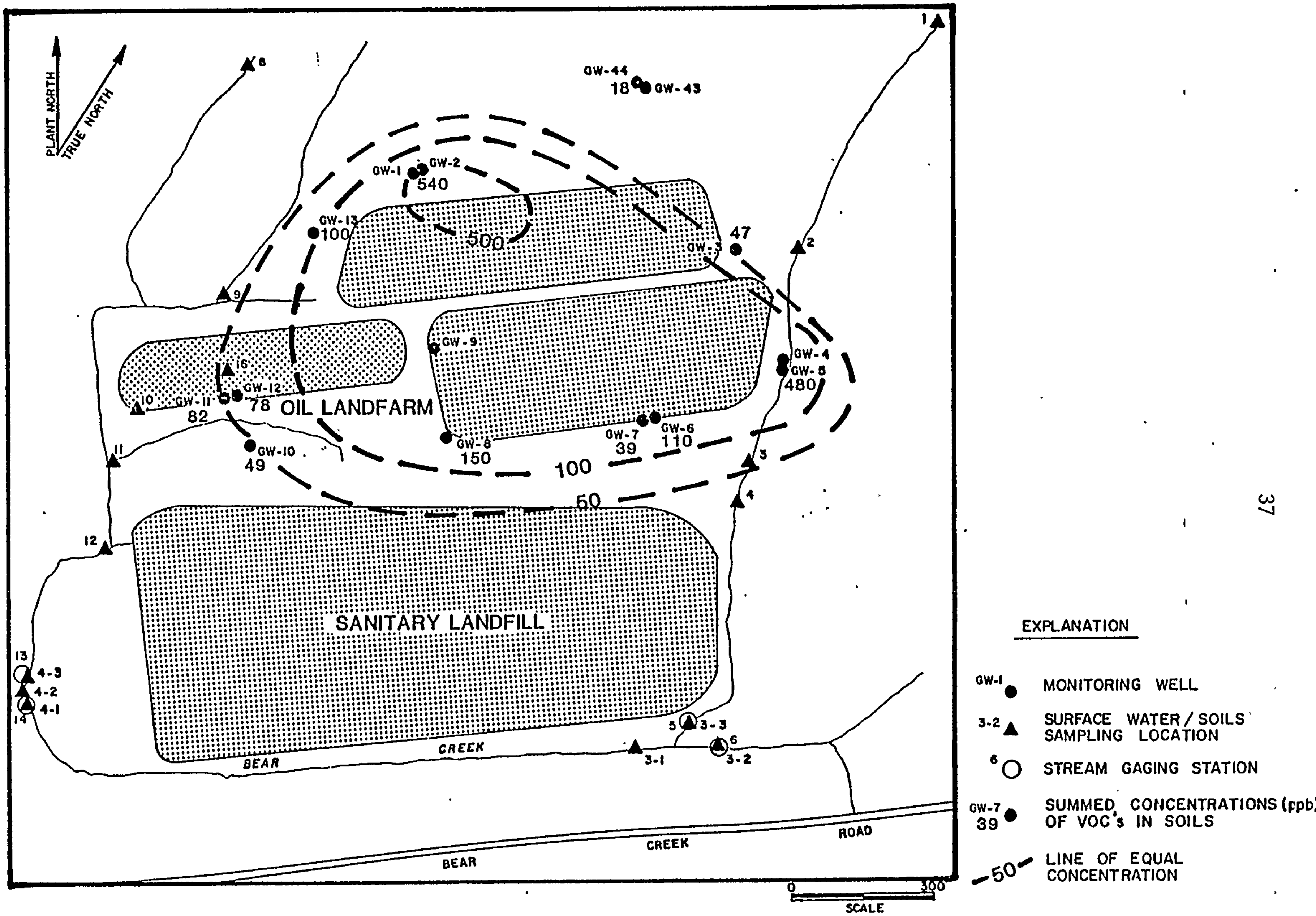


Figure 5-7. Summed Concentrations (ppb) of VOCs in Soils at the Oil Landfarm, March 1984.

6.0 IMPACT ASSESSMENT

6.1 FINDINGS TO DATE

The movement of leachate from the sources of wastes in Bear Creek Valley has resulted in contamination of surface water and shallow ground water. Where contaminants enter Bear Creek and its tributaries, through overland runoff or outward seepage of ground water, the result is a direct transport of the contaminants in a downstream direction. The limited water-quality data for Bear Creek show elevated concentrations of VOCs and nitrates at several of the sampling stations within the valley.

Ground water in the shallow geologic units close to the disposal sites shows a similar pattern of contamination by VOCs, metals, and other constituents. For the most part, the shallow plumes of contaminated ground water extend toward the tributaries, with the concentrations of dissolved constituents falling to below detection limits generally within a distance of about 1,000 feet from any waste source. The possibility exists that some contaminated ground water may have descended to depths below the zones penetrated by the existing monitor wells, but this hypothesis has yet to be tested. Information on this possibility will be compiled and evaluated as the investigative program continues.

Soils in the valley are contaminated, to some extent, in the vicinity of the waste sources and along stretches of Bear Creek, by VOCs, metals, and other constituents. The patterns of soil contamination generally reflect the patterns of shallow ground-water contamination. The overland movement of contaminated soils into Bear Creek and its tributaries is a matter of concern, inasmuch as those soils may continue to generate additional contaminants for

- transport downstream through the surface water system.

A principal concern of TDHE and EPA is the effects of past waste disposal practices on the biota of Bear Creek. Past investigations (see Appendix E) indicate that waste disposal operations in the Bear Creek drainage basin have had a significant adverse impact on the aquatic biota of Bear Creek. Based on the results of studies of the benthic macroinvertebrate communities conducted in the mid-1970s, the impact occurred over approximately 7 km of Bear Creek, from the headwaters below the S-3 ponds to Bear Creek Kilometer (BCK) 4.7 near the NPDES monitoring station. These data also indicated a general trend toward higher species diversity and abundance with increased distance downstream. Recent evidence suggests that some ecological recovery has occurred over the past 10 years. For example, fish were collected in 1984 from a reach of Bear Creek only 500 m below a site where <u>in situ</u> fish bioassays conducted in 1974 resulted in 100% mortality in 24 h. Although important pollution abatement achievements have occurred since 1974 (e.g., neutralization and denitrification of the S-3 ponds initiated in June 1983), no direct evidence exists of a casual relationship between reductions in pollutant discharges and changes in aquatic biota. To characterize the existing environment in Bear Creek prior to implementation of a remedial action plan for significantly reducing pollutant discharges in the watershed, ecological studies were initiated in April 1984 as a follow-on to a limited preliminary study undertaken in December 1983. These studies combine intensive field sampling of benthic macroinvertebrate and fish communities with diagnostic laboratory bioassays to obtain information on the identity and source(s) of contaminants that are toxic to biota. Appendix E is a more detailed preliminary report on the ecological impacts of past waste disposal operations along with a brief description of the studies currently in progress.

In the overall assessment of impacts, it is significant that no wells are in use for drinking water purposes in Bear Creek Valley. There has been some speculation regarding possible transport of contaminants toward wells far to the north or south, beneath the ridges bordering the valley, but this would seem to be a somewhat unlikely path of ground-water flow. An on-going investigation by the U.S. Geological Survey of the regional patterns of ground-water flow will address this matter.

Based on the information in-hand, on interpretations of that information by hydrologists, specialists in the area of contaminant transport, and ecologists, the situation in Bear Creek Valley appears not to represent an imminent hazard to public health. Based on studies of benthic macroinvertebrates near the NPDES monitoring station in the mid-1970s, the impact to aquatic biota occurred over approximately 7 km of Bear Creek.

The principal uncertainties regarding possible adverse impacts pertain to (1) biotic communities in the surface waters, (2) flows of contaminants into the deeper parts of the ground-water system, and (3) the more remote possibility of movement of contaminated ground water to the north or south beneath the ridges bordering the valley. All three of these potential types of impacts are under investigation, as explained in Chapter 8.0.

6.2 POTENTIAL CONTAMINANT MIGRATION

Figure 6-1 is a diagram of the major contaminant-migration pathways in Bear Creek Valley, prepared as a basis for considering options for remedial

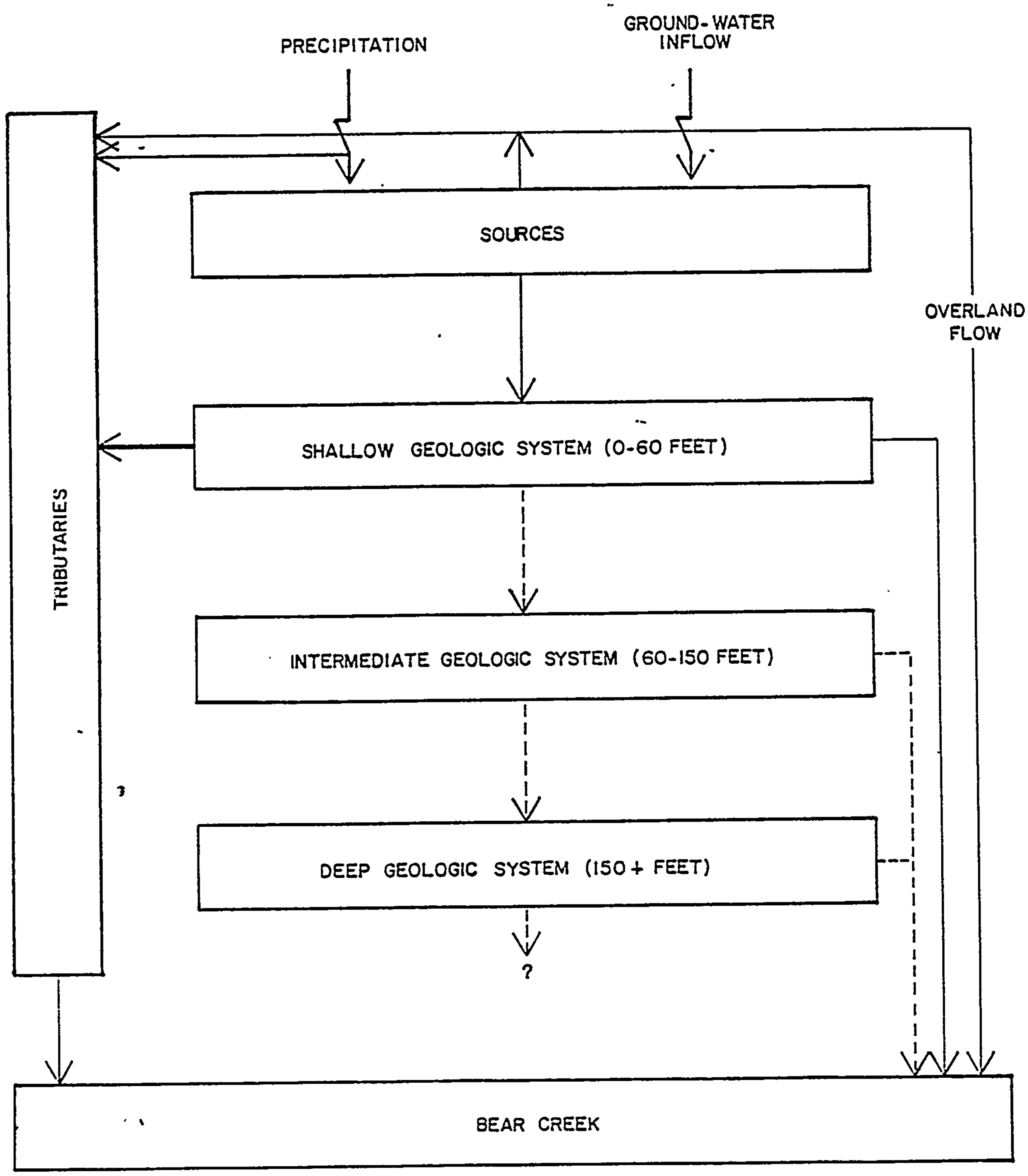


Figure 6-1. Schematic Diagram of Contaminant Migration Pathways.

action. The diagram indicates how water from precipitation moves through the waste sources, along with inflows of shallow ground water, to generate leachates that enter surface waters and ground waters. Because the evidence is conclusive for contamination of the tributaries of Bear Creek and of the shallow ground-water system (Chapter 5.0), those pathways are indicated by solid arrows on the illustration. Evidence for deeper circulation in the ground-water system is only fragmentary, and the arrows depicting those possible pathways are shown in dashed form. Any contaminants at these greater depths probably would ultimately seep out to enter Bear Creek itself, or less likely, to move beneath the bordering ridges.

Within the generalized flow pathways, a number of minor pathways may exist, making the detailed definition of flow quite complex. For example, it has been theorized that some of the existing wells may serve as vertical conduits, possibly allowing contaminants to enter the wells at a shallow depth for downward transport into deeper parts of the ground-water system. Such internal circulation in the wells can be evaluated only by comparisons of heads at different depths in the system — information which is not presently available but is currently being collected. Other data seem to show the presence of cavities in the shallow geologic formations, mainly underlying parts of the valley close to Bear Creek and Chestnut Ridge. Interconnected openings of this kind might represent still another subsurface pathway of flow that could partly short-circuit the regional patterns shown on Figure 6-1. The fact that Bear Creek seems to gain water and lose water along different stretches may be indirect evidence of circulation through cavernous zones close to the creek.

Deep circulation in the ground-water system is a major uncertainty in the overall analysis. An element of the on-going investigation specifically addresses this point, as described in Chapter 8.0. Still another consideration is the source of and movement of water toward the several springs that discharge south of Bear Creek. These springs may originate from either very deep parts of the ground-water system or from shallow ground waters in the valley. Obviously, a more detailed knowledge of the mechanisms governing spring flow would contribute to the overall assessment.

Variability in the production of leachate is another element about which little is known at this time. Capping of some of the waste disposal areas undoubtedly has reduced infiltration of precipitation, thereby lessening the production of leachate. However, some of the waste materials extend downward into the saturated zone, so that shallow ground water moving laterally may continue to generate leachate regardless of the presence of the caps.

From an overall perspective, it is believed that the major pathways of flow are those illustrated on Figure 6-1. It is not anticipated that localized deviations in this flow system would significantly alter the general picture of contamination, but each such potential pathway must be considered in detail before a specific remedial program can be designed and implemented.

7.0 ASSESSMENT OF POTENTIAL REMEDIAL ACTIONS

7.1 HISTORY OF REMEDIAL ACTION

Several remedial measures have been instituted in the waste disposal areas to mitigate further ground-water contamination. Significant among these were the amendments of certain burial ground practices involving the disposal of mop waters, oils, etc. Several disposal sites have been partially covered with native soils and regraded to minimize further leachate production. Two ponds were installed at the burial grounds to collect and contain oils that were discharging to tributaries to Bear Creek. In addition, in areas of current operations, the land surface was graded to control erosion and to redirect surface runoff and trenches have been made shallower to minimize contact with ground water. These measures represent an essential first step in the overall remedial action process.

More recently, an extensive drilling and water-sampling program has been instituted to provide data needed for selection of the most effective remedial options. New monitoring wells are being installed to various depths to better define the three-dimensional pattern of contamination. Still other investigations (i.e., mass-transport modeling) are planned (see Chapter 8.0) to provide information on other critical elements of the remedial program.

7.2 POTENTIAL REMEDIAL ACTION ALTERNATIVES

The range of choice in alternatives for remedial action is broad due to the diversity of waste sources, transport mechanisms, and the number of known or inferred points of impact discussed in Chapter 6.0. Conceivable remedial objectives range from complete removal of wastes to the minimum-action alternative of simply monitoring contaminant levels at key discharge points. Within this range, there are numerous strategies to be evaluated, including combinations of technologies, that can differ widely in cost, risk, and effectiveness.

For the purpose of this report, the alternatives have been grouped into three major types of control: source control, intermediate control, and discharge control, generally in conformance with the logic presented in the diagram on Figure 6-1. The concept of source control includes, at one extreme, physical removal of wastes by excavation or in-situ leaching, and also refers to installation of structures to block or minimize leachate production and to hydraulically isolate the disposal areas from the natural environment. The relevant technologies include caps, in-situ stabilization, slurry walls, drains, and grout curtains.

Intermediate control basically refers to the removal of contaminants that have migrated into and through the ground-water system from the disposal areas. This would be accomplished through installation of recovery wells or drains and treatment of the recovered water at locations in the immediate vicinity of the disposal areas. The emphasis of intermediate control is to remove the most highly contaminated ground water between the sources and the points of natural discharge.

Discharge control refers to the collection and treatment of fluids at or near key discharge points such as springs, water-supply wells, and streams. The pertinent collection technologies include drains, recovery wells, and other flow-control structures.

Elements of each approach can be used in combination with other techniques. For example, one possible remedial action is to only control the waste sources and the discharges of contaminants at key points. In that instance, the eventual removal of contaminants from the intervening ground water would be of secondary importance, as the major emphasis would be on protection of discharge points. Contaminant removal at the discharge points would eventually lead to removal in the intermediate areas, assuming source control. Many other combinations are possible, and their relative advantages/disadvantages are discussed in the following sections. Additional field analyses and possibly pilot testing will be needed before a final remedial plan can be designed.

7.3 SOURCE CONTROL

Source-control alternatives can be divided into two general classes, those minimizing further leachate production and those primarily directed toward waste removal. The overall objective of this strategy would be to minimize contaminant-mass releases.

To reduce leachate production, individual disposal sites can be capped, eliminating or greatly reducing infiltration of precipitation. This may be done in conjunction with a system of drains, wells, or slurry walls to reduce and/or control the lateral movement of shallow ground water beneath the disposal sites. Owing to heterogeneities and the lack of a well-defined confining unit in the shallow ground-water system, encapsulation using only a slurry wall/cap system may not be effective.

Structures to control flow would be located as close as possible to the boundaries of the disposal areas, depending on the flow-system characteristics and limitations imposed by the local topography. Caps generally could be constructed using membrane liners, clay over-fill, and topsoil/vegetative cover; surface water run-on/runoff would be controlled by grading and drainage ditches. Long-term maintenance would be required for both cover/cap materials and ground-water control structures. It should be noted that implementation of this strategy alone will not retard or reduce the migration of contaminants already in the ground-water system.

In-situ leaching, in which chemical solutions would be introduced into the waste areas to extract wastes for collection, treatment, and ultimate disposal, could eventually be considered to reduce the mass of waste stored at specific disposal sites. Evaluation of the needed recirculation and treatment systems would involve the estimation of removal rates, waste treatability, and ultimate residual contaminant levels. Years of pilot testing might be needed before a reliable estimate for this type of contaminant removal could be made.

Excavation may be considered to be impractical in certain areas as it could involve redisposal or destruction of large volumes of toxic or possibly explosive materials. In addition, health and safety considerations could preclude excavation in certain places (e.g., uranium disposal areas), where avoidance of chemical explosive hazards would be difficult or impossible.

7.4 INTERMEDIATE CONTROL

Intermediate control refers to the removal of ground water containing excessive concentrations of contaminants in places outside the immediate boundaries of the disposal areas. Wells or drains would be used in the removal process at locations showing the highest degree of contamination. The objective of this alternative is to remove as much of the contaminants as possible from the ground water, precluding further migration of contaminants toward discharge points.

Additional monitor wells would be installed to guide the selection of locations and depths of the recovery wells or drains, in order to intercept contaminated ground water most effectively. Some recovery wells might be as deep as several hundred feet if deep circulation of contaminants is identified.

The results of pump tests in the wells will provide needed information on well spacing and the extent of water-level drawdowns. In places heavily contaminated by floating oils, pumping of ground water may be delayed until surficial clean-up is achieved in order to prevent downward migration of contaminants due to lowering of ground-water levels. Because individual well yields are expected to be low (less than 10 gpm), well spacing could be fairly dense.

Treatment of the recovered water for removal of contaminants is expected to be costly and complex, due to the variety of chemical species and possibly to the dynamic mixtures involved. Initial pilot testing will be required before a full-scale plant can be designed. It is likely that a combination of pre-filtration, air stripping, granular-activated carbon, and chemical processes may be needed.

The duration of operation of the intermediate alternative depends on the pumping rates that can be maintained, heterogeneities in the flow system, and the degree of geochemical retardation or formation/contaminant reactivity. Assuming isolation or removal of the waste sources, the pumping activity could take decades to reduce sorbed contaminants to a stipulated level. Also, due to the low transmissivities of the geologic units, additional hydraulic control would be required to manage the less-contaminated ground water at the far edges of the defined plumes.

7.5 DISCHARGE CONTROL

The discharge-control alternative focuses on management of contaminated ground water at all points of discharge, in particular discharge to Bear Creek, to its tributaries, and to downgradient springs. The objective of this alternative is to protect the tributaries and Bear Creek by halting further migration of contaminants in the subsurface and controlling surface water runoff.

The contaminated ground water would be intercepted before discharging to surface water, using drains and recovery wells. The drains and wells would be placed in close proximity to the streams, with treated waters possibly being used to augment streamflows to make up for the intercepted baseflow. In both the intermediate and discharge-control alternatives, the withdrawal of ground water will result in a lowering of the water table, which may be partly offset by leakage from Bear Creek and its tributaries. Where streamflow augmentation with treated waters is not possible, water from some other source may have to be provided.

Because a downgradient spring is a natural point of discharge for ground water, it may be used for the collection of contaminated water at a relatively low cost. In this case, the flow of the spring would be diverted to a treatment system before discharging to Bear Creek.

Additional delineation of plumes will be required to identify downgradient discharge points. It is somewhat uncertain that Bear Creek captures all contaminated water in the valley, as discussed in Chapter 6.0, so that possible movement of contaminants beneath the stream will have to be verified and, if present in unacceptable concentrations, controlled.

Under the discharge-control alternative, the pumpage from wells and drains will be at rates just sufficient for plume containment and slow contaminant removal. This will minimize hydraulic impacts to the streams and the ground-water system in general. The duration of operation for discharge control, in the absence of source and intermediate control, cannot be determined with the available data base, but is probably on the order of many decades at least. The major advantage of discharge control is that compared to the other two control alternatives it offers a quicker way of restoring Bear Creek to its background condition. It does not, however, eliminate the source of the contamination.

8.0 THE PHASE II PROGRAM

8.1 GENERAL OBJECTIVES

The Phase II investigation will focus on designing a remedial-action option for the burial grounds and the oil landfarm. The option will be selected from several remedial-action alternatives, and may be a combination of two or more alternatives (see Chapter 7.0).

Prior to final selection, the DOE will enter into negotiations with TDHE and EPA to establish the biological and water-quality standards to be met at specified compliance points. These points may include a specific water-quality sampling station on Bear Creek, well cluster(s) at a specific distance downgradient of the Y-12 facility, or well cluster(s) at a specific distance downgradient of individual disposal sites. The negotiations will also address the timetable, with milestones for clean-up phases, that eventually will lead to compliance with specified standards. The on-going investigation will provide the technical basis for establishing the compliance program, including the compliance point(s), timetable, and standards.

The investigation planned at the waste disposal areas can be divided into three principal categories, namely, (1) assessment of environmental impacts, (2) definition of flow systems, and (3) initial design of remedial components. Some of the specific tasks to be accomplished will provide data for more than one of the three categories.

8.2 PLANNED INVESTIGATIONS FOR SELECTING ALTERNATIVES

8.2.1 Assessment of Environmental Impacts

The identified points of impact in the valley are (1) the ecological system, (2) the ground-water system, (3) water in Bear Creek and its tributaries, and (4) soils and sediments. The principal tasks to be accomplished to assess the impacts are:

- Completion of a one-year ecological impact report by July 1, 1985. (Appendix E)
- Evaluation of the integrity of wells in which intrafomational flow of contaminants may be taking place.
- Installation of a series of monitor wells at the S-3 ponds.
- Installation of deep wells to delineate the extent of contamination in the deeper parts of the ground-water system.
- Establishment of a routine water-sampling program at stations along Bear Creek and its tributaries.
- Determination of physical and chemical properties of sediments and soils in the beds of Bear Creek and its tributaries.

8.2.2 Definition of Flow Systems

The major flow elements to be investigated are: (1) ground-water movement in the shallow and deep geologic units, (2) runoff and flows through Bear Creek and its tributaries, and (3) surface water/ground water interrelationships. The principal tasks to be accomplished to define the flow systems are:

- o Preparation of water-table and potentiometric maps for the S-3 pond area.
- o Installation of deep wells to help define three-dimensional flow patterns.
- o Installation of automatic water-level recording instruments on monitor wells.
- o Performance of pumping tests in selected wells to define hydraulic characteristics of the aquifers.
- o Gaging of Bear Creek and its tributaries.
- o Collection of meteorlogical data from a station to be installed in the valley.
- o Calculation of an overall water budget for Bear Creek Valley.
- o Installation of borings/test wells along Bear Creek at presumed locations of cavernous zones.

8.2.3 Design of Remedial Components

The principal elements to be investigated under this heading are options for cleanup including: (1) treatment-plant design, (2) design of pumping wells and drains, (3) testing of the integrity and effectiveness of existing caps, (4) feasibility of installing slurry walls, (5) cleanup or removal of material, and (6) in situ fixation. The principal tasks to be accomplished are:

- Calculation of design flows.
- Estimation of seasonal variations in chemical composition of influents.
- Selection of optimal locations for treatment facilities.
- Pilot testing of recovery well/drain systems.
- Installation of test borings at candidate locations for slurry walls.
- Measurement of thickness and vertical permeabilities of cap materials.
- Development of a flow/mass-transport model to determine optimum pumping rates and locations for recovery well/drain systems.

- o Evaluation of techniques for soil and waste removal or cleanup
- o Evaluation of in situ fixation technology
- o Preparation of a report defining the design features and the effectiveness of a final remedial action plan.

8.3 SCHEDULING

An estimated 14 months will be required to complete the proposed investigation and remedial-action engineering options study. An additional period of time would, of course, be required to prepare working design documents for any construction. First, collection of the technical data will begin. The existing and potential ecological and water-quality impacts will be evaluated based on the data and on the computer analyses which will simulate existing and future water-quality impacts. The DOE will negotiate the biological and water-quality standards to be met at compliance point(s) established at the site. The best closure technology then can be selected by DOE, to be approved by TDHE and EPA. Finally, the design can commence and the components of the design can be implemented. Table 8-1 is the proposed schedule for the Phase II program.

TABLE 8-1

PROPOSED SCHEDULE FOR PHASE II PROGRAM

Jul - Sep 1984	o Meet with EPA and TDHE, review contents of Report Y/TS-51/1 and, obtain concurrence and guidance pertaining to Phase II Program
	o Issue data package reports* on ground water, surface water, soils, and, sediments
	o Issue preliminary data package report* on flows in Bear Creek
Oct - Dec 1984	o Meet with EPA and TDHE and review results of data collected in previous quarter and status reports on selected studies
	o Issue data package reports* on ground water, surface water, soils, and sediments
	o Issue interim report on ecological studies
	o Issue preliminary report on S-3 pond contaminant plume
	o Issue preliminary report on deep well monitoring program
Jan - Mar 1985	o Meet with EPA and TDHE and review results on data collected in previous quarter and status reports on selected studies
	o Reach agreement with TDHE and EPA on standards and compliance points.
	o Issue data package reports* on ground water, surface water, soils, and sediments
	o Issue interim report on flows in Bear Creek
	o Issue preliminary findings report on solution cavities in Bear Creek Valley
	o Issue preliminary findings report on seasonal variations in chemical composition of influents

TABLE 8-1 (Cont.)

Apr - Jun 1985	o Meet with EPA and TDHE and review results of data collected in previous quarter and status reports on selected studies
	o Issue data package reports* on ground water, surface water, soils, and sediments
	o Issue annotated outline of remedial action alternatives report to be provided to TDHE and EPA on July 1, 1985
	o Issue Remedial Action Alternatives Report

* Will include preliminary review and analysis of noteworthy data and findings.